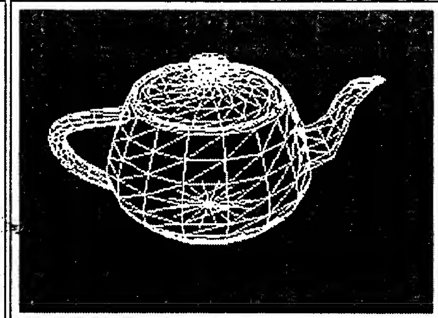
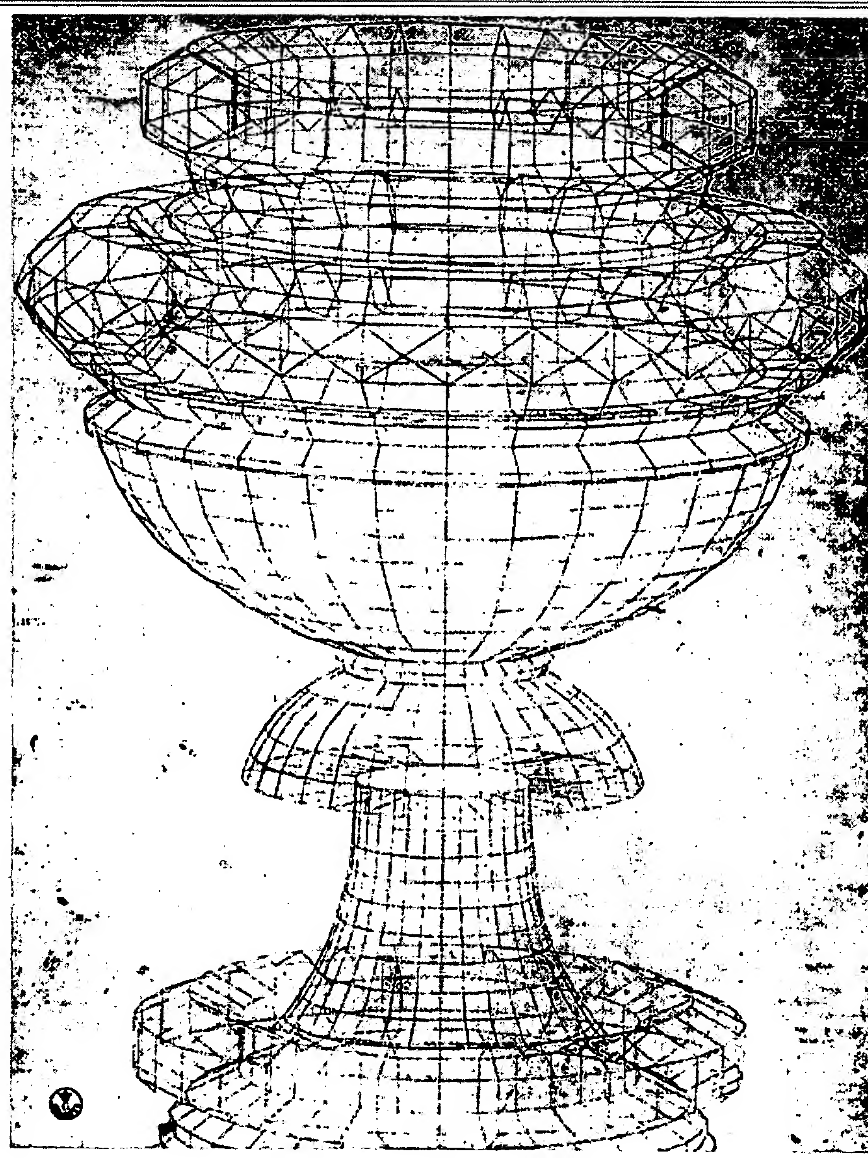
Polygon Mesh Data Structure for 3D Graphics

Introduction

The polygon mesh data structure is the most common and oldest modeling method for computer graphics.

Here is a wireframe teapot.	
Here is a pen and ink drawing of a wireframe chalice ("Perspective Study of a Chalice"), done by Paolo Uccelloin 1430-1440, Florence, Italy.	

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1 Structured visibility profiles with applications to problems in simple polygons (extended abstract) 100%
Paul J. Heffernan , Joseph S. B. Mitchell
Proceedings of the sixth annual symposium on Computational geometry May 1990
A number of problems in computational geometry involving simple polygons can be solved in linear time once the polygon has been triangulated. Since the worst-case time bound for triangulating a general simple polygon is currently super-linear, these algorithms are not linear time in the worst case. In this paper we define the structured visibility profile of a polygonal path and show how to compute it in linear time. We apply this result to solve many problems in linear tim ...

2 Detection of constrictions on closed polyhedral surfaces 100%
F. Hétroy , D. Attali
Proceedings of the symposium on Data visualisation 2003 May 2003
We define constrictions on a surface as simple closed geodesic curves, i.e. curves whose length is locally minimal. They can be of great interests in order to cut the surface in smaller parts. In this paper, we present a method to detect constrictions on closed triangulated surfaces. Our algorithm is based on a progressive approach. First, the surface is simplified by repeated edge collapses. The simplification continues until we detect an edge whose collapse would change the topology of the sur ...

3 Path planning in 0/1/ weighted regions with applications 100%
L. Gewali , A. Meng , J. S. Mitchell , S. Ntafos
Proceedings of the fourth annual symposium on Computational geometry January 1988
We consider the terrain navigation problem in a two-dimensional polygonal subdivision consisting of obstacles, “free” regions (in which one can travel at no cost), and regions in which cost is proportional to distance traveled. This problem is a special case of the weighted region problem and is a generalization of the well-known planar shortest path problem

09/515, 517

Citation

International Conference on Computer Graphics and Interactive Techniques >archive
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1997 ,

Interactive multiresolution mesh editing

Authors

Denis Zorin
Peter Schröder
Wim Sweldens

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Sanjini Jayaraman , Chris North
Proceedings of the conference on Visualization '02 October 2002
The analysis of multidimensional functions is important in many engineering disciplines, and poses a major problem as the number of dimensions increases. Previous visualization approaches focus on representing three or fewer dimensions at a time. This paper presents a new focus+context visualization that provides an integrated overview of an entire multidimensional function space, with uniform treatment of all dimensions. The overview is displayed with respect to a user-controlled polar focal po ...

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1 Poster session: Feature preserving manifold mesh from an octree 100%
Koji Ashida , Norman I. Badler
Proceedings of the eighth ACM symposium on Solid modeling and applications June 2003
We describe an algorithm to generate a manifold mesh from an octree while preserving surface features. The algorithm requires samples of a surface (coordinates) on the octree edges, along with the surface normals at those coordinates.The distinct features of the algorithm are:

- the output mesh is manifold,
- the resolution of the output mesh can be adjusted over the space with octree subdivision, and
- surface features are generally preserved.

A mesh generation algorit ...

2 Session P12: meshes: Bounded-distortion piecewise mesh parameterization 100%
Olga Sorkine , Daniel Cohen-Or , Rony Goldenthal , Dani Lischinski
Proceedings of the conference on Visualization '02 October 2002
Many computer graphics operations, such as texture mapping, 3D painting, remeshing, mesh compression, and digital geometry processing, require finding a low-distortion parameterization for irregular connectivity triangulations of arbitrary genus 2-manifolds. This paper presents a simple and fast method for computing parameterizations with strictly bounded distortion. The new method operates by flattening the mesh onto a region of the 2D plane. To comply with the distortion bound, the mesh is aut ...

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1 Navigating through triangle meshes implemented as linear quadtrees 97%
Michael Lee , Hanan Samet
ACM Transactions on Graphics (TOG) April 2000
Volume 19 Issue 2
Techniques are presented for navigating between adjacent triangles of greater or equal size in a hierarchical triangle mesh where the triangles are obtained by a recursive quadtree-like subdivision of the underlying space into four equilateral triangles. These techniques are useful in a number of applications, including finite element analysis, ray tracing, and the modeling of spherical data. The operations are implemented in a manner analogous to that used in a quadtree representation of d ...

2 Ray shooting and other applications of spanning trees with low stabbing number 90%
P. K. Agarwal
Proceedings of the fifth annual symposium on Computational geometry June 1989
In this paper we consider the following problem: Given a set @@@@ of n (possibly intersecting) line segments in the plane, preprocess them so that, given a query ray &rgr; emanating from a point p, we can quickly compute the intersection point &PHgr;(@@@@, &rgr;) of &rgr; with a segment of @@@@ that lies nearest to p. We present an algorithm that preprocesses @@@@, in time &Ogr;

3 WYSIWYG NPR: drawing strokes directly on 3D models 88%
Robert D. Kalnins , Lee Markosian , Barbara J. Meier , Michael A. Kowalski , Joseph C. Lee , Philip L. Davidson , Matthew Webb , John F. Hughes , Adam Finkelstein
ACM Transactions on Graphics (TOG) , Proceedings of the 29th annual conference on Computer graphics and interactive techniques July 2002
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We present a system that lets a designer directly annotate a 3D model with strokes, imparting a

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1 Creating polyhedral stellations 100%
Kathleen R. McKeown , Norman I. Badler
Proceedings of the 7th annual conference on Computer graphics and interactive techniques July 1980
A process for creating and displaying stellations of a given polyhedral solid is described. A stellation is one of many star-like polyhedra which can be derived from a single solid by extending its existing faces. A program has been implemented which performs the stellation process on an input object and generates a 3-dimensional image of the stellated object on a computer graphics display screen. Pictures of icosahedron and rhombictriacontahedron stellations generated by the program are in ...

2 Poster session: Feature preserving manifold mesh from an octree 100%
Koji Ashida , Norman I. Badler
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3 Applications of random sampling in computational geometry, II 100%
K. L. Clarkson
Proceedings of the fourth annual symposium on Computational geometry January 1988

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1 Navigating through triangle meshes implemented as linear quadtrees — 100%

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2 Solid representation and operation using extended octrees — 100%

Pere Brunet

ACM Transactions on Graphics (TOG) April 1990

Volume 9 Issue 2

Solid modelers must be based on reliable and fast algorithms for Boolean operations. The octree model, as well as several generalizations (polytrees, integrated polytrees, extended octrees), is specially well suited for these algorithms and can be used either as a primary or as a secondary model in solid modeling systems. This paper is concerned with a precise definition of the extended octree model that allows the representation of nonmanifold objects with planar faces and, consequently, i ...

3 Object representation by means of nonminimal division quadtrees and octrees — 99%

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1 Kizamu: a system for sculpting digital characters 94%
Ronald N. Perry , Sarah F. Frisken
Proceedings of the 28th annual conference on Computer graphics and interactive techniques
August 2001

This paper presents Kizamu, a computer-based sculpting system for creating digital characters for the entertainment industry. Kizamu incorporates a blend of new algorithms, significant technical advances, and novel user interaction paradigms into a system that is both powerful and unique.

To meet the demands of high-end digital character design, Kizamu addresses three requirements posed to us by a major production studio. First, animators and artists want *digital clay* — a ...

2 Gross motion planning—a survey 92%
Yong K. Hwang , Narendra Ahuja
ACM Computing Surveys (CSUR) September 1992
Volume 24 Issue 3
Motion planning is one of the most important areas of robotics research. The complexity of the motion-planning problem has hindered the development of practical algorithms. This paper surveys the work on gross-motion planning, including motion planners for point robots, rigid robots, and manipulators in stationary, time-varying, constrained, and movable-object environments. The general issues in motion planning are explained. Recent approaches and their performances are briefly described, a ...

3 MAPS: multiresolution adaptive parameterization of surfaces 91%

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3 Detection of constrictions on closed polyhedral surfaces 100%
F. Hétroy , D. Attali
Proceedings of the symposium on Data visualisation 2003 May 2003

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4 Applications of random sampling in computational geometry, II 100%
K. L. Clarkson
Proceedings of the fourth annual symposium on Computational geometry January 1988
Random sampling is used for several new geometric algorithms. The algorithms are “Las Vegas,” and their expected bounds are with respect to the random behavior of the algorithms. One algorithm reports all the intersecting pairs of a set of line segments in the plane, and requires &Ogr;(A + n log n) expected time, where A is the size of the answer, the number of intersecting pairs reported. The a ...

5 A multisided generalization of Bézier surfaces 100%
Charles T. Loop , Tony D. DeRose
ACM Transactions on Graphics (TOG) July 1989
Volume 8 Issue 3
In this paper we introduce a class of surface patch representations, called S-patches, that unify and generalize triangular and tensor product Bézier surfaces by allowing patches to be defined over any convex polygonal domain; hence, S-patches may have any number of boundary curves. Other properties of S-patches are geometrically meaningful control points, separate control over positions and derivatives along boundary curves, and a geometric construction algorithm based on de Castelj ...

6 Session 5: simplification and meshes: User-controlled creation of multiresolution meshes 100%
Erik Pojar , Dieter Schmalstieg
Proceedings of the 2003 symposium on Interactive 3D graphics April 2003
We present a tool for the user-controlled creation of multiresolution meshes. Most automatic mesh reduction methods are not able to identify mesh regions of high semantic or functional importance, for example the face of a character model or areas deformed by animation. To address this problem, we present a method allowing a user to provide importance weights for mesh regions to control the automatic simplification process. To demonstrate the usefulness of this approach in a real world setting, ...

7 Meshes: Adjacency and incidence framework: a data structure for efficient and fast management of multiresolution meshes 100%
Frutuoso G. M. Silva , Abel J. P. Gomes
Proceedings of the 1st international conference on Computer graphics and interactive techniques in Austalasia and South East Asia February 2003
This paper introduces a concise and responsiveness data structure, called AIF (Adjacency and Incidence Framework), for multiresolution meshes, as well as a new simplification algorithm based on the planarity of neighboring faces. It is an optimal data structure for polygonal meshes, manifold and non-manifold, which means that a minimal number of direct and indirect accesses are required to retrieve adjacency and incidence information from it. These querying tools are necessary for dynamic multir ...

8 Session P15: multidimensional, motion, and information visualization: A radial focus+context visualization for multi-dimensional functions 100%
Sanjini Jayaraman , Chris North
Proceedings of the conference on Visualization '02 October 2002
The analysis of multidimensional functions is important in many engineering disciplines, and poses a major problem as the number of dimensions increases. Previous visualization approaches focus on representing three or fewer dimensions at a time. This paper presents a new focus+context visualization that provides an integrated overview of an entire multidimensional function space, with uniform treatment of all dimensions. The overview is displayed with respect to a user-controlled polar focal po ...

9 Session P4: compression and simplification: TetFusion: an algorithm for rapid tetrahedral mesh simplification 100%
Prashant Chopra , Joerg Meyer
Proceedings of the conference on Visualization '02 October 2002
This paper introduces an algorithm for rapid progressive simplification of tetrahedral meshes: *TetFusion*. We describe how a simple geometry decimation operation steers a rapid and controlled progressive simplification of tetrahedral meshes, while also taking care of complex mesh-inconsistency problems. The algorithm features a high decimation ratio per step, and inherently discourages any cases of self-intersection of boundary, element-boundary intersection at concave boundary-regions, an ...

10 Robust epsilon visibility 100%
Florent Duguet , George Drettakis
ACM Transactions on Graphics (TOG) , Proceedings of the 29th annual conference on Computer graphics and interactive techniques July 2002
Volume 21 Issue 3
Analytic visibility algorithms, for example methods which compute a subdivided mesh to represent shadows, are notoriously unrobust and hard to use in practice. We present a new method based on a generalized definition of extremal stabbing lines, which are the extremities of shadow boundaries. We treat scenes containing multiple edges or vertices in degenerate configurations, (e.g., collinear or coplanar). We introduce a robust ε method to determine whether each generalized extremal stabb ...

11 A procedural approach to authoring solid models 100%
Barbara Cutler , Julie Dorsey , Leonard McMillan , Matthias Müller , Robert Jagnow
ACM Transactions on Graphics (TOG) , Proceedings of the 29th annual conference on Computer graphics and interactive techniques July 2002
Volume 21 Issue 3
We present a procedural approach to authoring layered, solid models. Using a simple scripting language, we define the internal structure of a volume from one or more input meshes. Sculpting and simulation operators are applied within the context of the language to shape and modify the model. Our framework treats simulation as a modeling operator rather than simply as a tool for animation, thereby suggesting a new paradigm for modeling as well as a new level of abstraction for interacting with si ...

12 Static and kinetic geometric spanners with applications 100%

Menelaos I. Karavelas , Leonidas J. Guibas
Proceedings of the twelfth annual ACM-SIAM symposium on Discrete algorithms January 2001

It is well known that the Delaunay Triangulation is a spanner graph of its vertices. In this paper we show that any bounded aspect ratio triangulation in two and three dimensions is a spanner graph of its vertices as well. We extend the notion of spanner graphs to environments with obstacles and show that both the Constrained Delaunay Triangulation and bounded aspect ratio conforming triangulations are spanners with respect to the corresponding visibility graph. We also show how to kinetiz ...

13 Frame-to-frame coherence and the hidden surface computation: constraints for a convex world 100%
H. Hubschman , S. W. Zucker
ACM Transactions on Graphics (TOG) April 1982
Volume 1 Issue 2

14 A Characterization of Ten Hidden-Surface Algorithms 100%
Evan E. Sutherland , Robert F. Sproull , Robert A. Schumacker
ACM Computing Surveys (CSUR) January 1974
Volume 6 Issue 1

15 Shadows for cel animation 100%
Lena Petrovi? , Brian Fujito , Lance Williams , Adam Finkelstein
Proceedings of the 27th annual conference on Computer graphics and interactive techniques July 2000
We present a semi-automatic method for creating shadow mattes in cel animation. In conventional cel animation, shadows are drawn by hand, in order to provide visual cues about the spatial relationships and forms of characters in the scene. Our system creates shadow mattes based on hand-drawn characters, given high-level guidance from the user about depths of various objects. The method employs a scheme for “inflating” a 3D figure based on hand-drawn art. It provides simple tools ...

16 Lapped textures 100%
Emil Praun , Adam Finkelstein , Hugues Hoppe
Proceedings of the 27th annual conference on Computer graphics and interactive techniques July 2000
We present for creating texture over an surface mesh using an example 2D texture. The approach is to identify interesting regions (texture patches) in the 2D example, and to repeatedly paste them onto the surface until it is completely covered. We call such a collection of overlapping patches a lapped texture. It is rendered using compositing operations, either into a traditional global texture map during a preprocess, or directly with the surface at runtim ...

17 Face fixer: compressing polygon meshes with properties 100%
Martin Isenburg , Jack Snoeyink
Proceedings of the 27th annual conference on Computer graphics and interactive techniques July 2000
Most schemes to compress the topology of a surface mesh have been developed for the lowest common denominator: triangulated meshes. We propose a scheme that handles the topology of

arbitrary polygon meshes. It encodes meshes directly in their polygonal representation and extends to capture face groupings in a natural way. Avoiding the triangulation step we reduce the storage costs for typical polygon models that have group structures and property data.

100%

18 Parallel multigrid solver for 3D unstructured finite element problems
Mark Adams , James W. Demmel
Proceedings of the 1999 ACM/IEEE conference on Supercomputing (CDROM) January 1999

100%

19 Implant sprays: compression of progressive tetrahedral mesh connectivity
Renato Pajarola , Jarek Rossignac , Andrzej Szymczak
Proceedings of the conference on Visualization '99: celebrating ten years October 1999
Irregular tetrahedral meshes, which are popular in many engineering and scientific applications, often contain a large number of vertices. A mesh of V vertices and T tetrahedra requires 48·V bits or less to store the vertex coordinates, 4·Vlog2 bits to store the tetrahedra-vertex incidence relations, also called connectivity information, and k·V bits to store the k-bit value samples associated with the vertices. Given that T is 5 to 7 times ...

100%

20 Optimization problems related to zigzag pocket machining
Esther M. Arkin , Martin Held , Christopher L. Smith
Proceedings of the seventh annual ACM-SIAM symposium on Discrete algorithms January 1996

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1 Creating polyhedral stellations 100%

Kathleen R. McKeown , Norman I. Badler

Proceedings of the 7th annual conference on Computer graphics and interactive techniques

July 1980

A process for creating and displaying stellations of a given polyhedral solid is described. A stellation is one of many star-like polyhedra which can be derived from a single solid by extending its existing faces. A program has been implemented which performs the stellation process on an input object and generates a 3-dimensional image of the stellated object on a computer graphics display screen. Pictures of icosahedron and rhombictriacontahedron stellations generated by the program are in ...

2 Building a scaleable geo-spatial DBMS: technology, implementation, and evaluation 100%

Jignesh Patel , JieBing Yu , Navin Kabra , Kristin Tufte , Biswadeep Nag , Josef Burger , Nancy Hall , Karthikeyan Ramasamy , Roger Lueder , Curt Ellmann , Jim Kupsch , Shelly Guo , Johan Larson , David De Witt , Jeffrey Naughton

ACM SIGMOD Record , Proceedings of the 1997 ACM SIGMOD international conference on Management of data June 1997

Volume 26 Issue 2

This paper presents a number of new techniques for parallelizing geo-spatial database systems and discusses their implementation in the Paradise object-relational database system. The effectiveness of these techniques is demonstrated using a variety of complex geo-spatial queries over a 120 GB global geo-spatial data set.

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1 Multiresolution analysis for surfaces of arbitrary topological type 99%
Michael Lounsbery , Tony D. DeRose , Joe Warren
ACM Transactions on Graphics (TOG) January 1997
Volume 16 Issue 1
Multiresolution analysis and wavelets provide useful and efficient tools for representing functions at multiple levels of detail. Wavelet representations have been used in a broad range of applications, including image compression, physical simulation, and numerical analysis. In this article, we present a new class of wavelets, based on subdivision surfaces, that radically extends the class of representable functions. Whereas previous two-dimensional methods were restricted to functions dif ...

2 Multiresolution analysis of arbitrary meshes 97%
Matthias Eck , Tony DeRose , Tom Duchamp , Hugues Hoppe , Michael Lounsbery , Werner Stuetzle
Proceedings of the 22nd annual conference on Computer graphics and interactive techniques September 1995

3 Interactive multiresolution surface viewing 87%
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Proceedings of the 23rd annual conference on Computer graphics and interactive techniques August 1996

4 Interactive multiresolution mesh editing 85%
Denis Zorin , Peter Schröder , Wim Sweldens
Proceedings of the 24th annual conference on Computer graphics and interactive techniques August 1997

5 Meshes: Consistent parametrization by quinary subdivision for remeshing and mesh metamorphosis 84%
Jian Liang Lin , Jung Hong Chuang , Cheng Chung Lin , Chih Chun Chen
Proceedings of the 1st international conference on Computer graphics and interactive techniques in Austalasia and South East Asia February 2003
The vertex correspondence establishment among multiple objects is a versatile operation in computer graphics and geometry processing. We propose a systematic method called *recursive quinary subdivision* to efficiently find a dissection for a meshed object of genus-zero with little user input. The process can be easily extended to multiple objects, taking into account the alignment of extra feature points for applications such as mesh metamorphosis, to derive a common dissection. Based on t ...

6 Session D: Geometry: View-dependent refinement of multiresolution meshes with subdivision connectivity 84%
Daniel I. Azuma , Daniel N. Wood , Brian Curless , Tom Duchamp , David H. Salesin , Werner Stuetzle
Proceedings of the 2nd international conference on Computer graphics, virtual Reality, visualisation and interaction in Africa February 2003
We present a view-dependent level-of-detail algorithm for triangle meshes with subdivision connectivity. The algorithm is more suitable for textured meshes of arbitrary topology than existing progressive mesh-based schemes. It begins with a wavelet decomposition of the mesh, and, per frame, finds a partial sum of wavelets necessary for high-quality renderings from that frame's viewpoint. We present a screen-space error metric that measures both geometric and texture deviation and tends to outper ...

7 Model Simplification: Biorthogonal wavelets for subdivision volumes 84%
Martin Bertram
Proceedings of the seventh ACM symposium on Solid modeling and applications June 2002
We present a biorthogonal wavelet construction based on Catmull-Clark-style subdivision volumes. Our wavelet transform is the three-dimensional extension of a previously developed construction of subdivision-surface wavelets that was used for multiresolution modeling of large-scale isosurfaces. Subdivision surfaces provide a flexible modeling tool for surfaces of arbitrary topology and for functions defined thereon. Wavelet representations add the ability to compactly represent large-scale geome ...

8 Bicubic subdivision-surface wavelets for large-scale isosurface representation and visualization 84%
Martin Bertram , Mark A. Duchaineau , Bernd Hamann , Kenneth I. Joy
Proceedings of the conference on Visualization '00 October 2000

9 MetaStream 84%
Vadim Abadjev , Miguel del Rosario , Alexei Lebedev , Alexander Migdal , Victor Paskhaver
Proceedings of the fourth symposium on Virtual reality modeling language February 1999

10 Progressive meshes 84%
Hugues Hoppe
Proceedings of the 23rd annual conference on Computer graphics and interactive

techniques August 1996

11 Multiresolution curves 84%

Adam Finkelstein , David H. Salesin

Proceedings of the 21st annual conference on Computer graphics and interactive techniques July 1994

We describe a multiresolution curve representation, based on wavelets, that conveniently supports a variety of operations: smoothing a curve; editing the overall form of a curve while preserving its details; and approximating a curve within any given error tolerance for scan conversion. We present methods to support continuous levels of smoothing as well as direct manipulation of an arbitrary portion of the curve; the control points, as well as the discrete nature of the underlying hierarch ...

12 MAPS: multiresolution adaptive parameterization of surfaces 83%

Aaron W. F. Lee , Wim Sweldens , Peter Schröder , Lawrence Cowsar , David Dobkin

Proceedings of the 25th annual conference on Computer graphics and interactive techniques July 1998

13 Cut-and-paste editing of multiresolution surfaces 82%

Henning Biermann , Ioana Martin , Fausto Bernardini , Denis Zorin

ACM Transactions on Graphics (TOG) , Proceedings of the 29th annual conference on Computer graphics and interactive techniques July 2002

Volume 21 Issue 3

Cutting and pasting to combine different elements into a common structure are widely used operations that have been successfully adapted to many media types. Surface design could also benefit from the availability of a general, robust, and efficient cut-and-paste tool, especially during the initial stages of design when a large space of alternatives needs to be explored. Techniques to support cut-and-paste operations for surfaces have been proposed in the past, but have been of limited usefulnes ...

14 Displaced subdivision surfaces 82%

Aaron Lee , Henry Moreton , Hugues Hoppe

Proceedings of the 27th annual conference on Computer graphics and interactive techniques July 2000

In this paper we introduce a new surface representing, the displaced subdivision surface. It represents a detailed surface model as a scalar-valued displacement over a smooth domain surface. Our representation defines both the domain surface and the displacement function using a unified subdivision framework, allowing for simple and efficient evaluation of analytic surface properties. We present a simple, automatic scheme for converting detailed geometric models into such a ...

15 Prefix compression of sparse binary strings 82%

David Salomon

Crossroads March 2000

Volume 6 Issue 3

16 XVL: a compact and qualified 3D representation with lattice mesh and surface for the Internet 82%

Akira Wakita , Makoto Yajima , Tsuyoshi Harada , Hiroshi Toriya , Hiroaki Chiyokura
Proceedings of the fifth symposium on Virtual reality modeling language (Web3D-VRML)
February 2000
Computer graphics systems and CAD/CAM systems are widely used and an abundance of 3D-Data in various fields exists. However, based on the VRML technique, it is difficult to send such 3D-Data through the Internet, because of the large data size. Transmission of practical and highly detailed 3D-Data through the Internet becomes a primary requirement.Therefore, a compact and qualified 3D-Data representation method is greatly required. This paper describes XVL (eXtended VRML with Lat ...

17 Compression of time-dependent geometry 82%
Jerome Edward Lengyel
Proceedings of the 1999 symposium on Interactive 3D graphics April 1999

18 Efficient, fair interpolation using Catmull-Clark surfaces 82%
Mark Halstead , Michael Kass , Tony DeRose
Proceedings of the 20th annual conference on Computer graphics and interactive techniques
September 1993

19 Surfaces from contours 82%
David Meyers , Shelley Skinner , Kenneth Sloan
ACM Transactions on Graphics (TOG) July 1992
Volume 11 Issue 3
This paper is concerned with the problem of reconstructing the surfaces of three-dimensional objects, given a collection of planar contours representing cross-sections through the objects. This problem has important aplications in biomedical research and instruction, solid modeling, and industrial inspection. The method we describe produces a triangulated mesh from the data points of the contours which is then used in conjunction with a piecewise parametric surface-fitting algori ...

20 Meshes: Adjacency and incidence framework: a data structure for efficient and fast management of multiresolution meshes 82%
Frutuoso G. M. Silva , Abel J. P. Gomes
Proceedings of the 1st international conference on Computer graphics and interactive techniques in Austalasia and South East Asia February 2003
This paper introduces a concise and responsiveness data structure, called AIF (Adjacency and Incidence Framework), for multiresolution meshes, as well as a new simplification algorithm based on the planarity of neighboring faces. It is an optimal data structure for polygonal meshes, manifold and non-manifold, which means that a minimal number of direct and indirect accesses are required to retrieve adjacency and incidence information from it. These querying tools are necessary for dynamic multir ...

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To Mary

To Debb
my child

To Jenni,

To my fa
my father

And to al

10.4 Input Handling in Window Systems 447
10.5 Interaction-Technique Toolkits 451
10.6 User-Interface Management Systems 456
Exercises 468

CHAPTER 11
REPRESENTING CURVES AND SURFACES **471**

11.1 Polygon Meshes 473
11.2 Parametric Cubic Curves 478
11.3 Parametric Bicubic Surfaces 516
11.4 Quadric Surfaces 528
11.5 Summary 529
Exercises 530

CHAPTER 12
SOLID MODELING **533**

12.1 Representing Solids 534
12.2 Regularized Boolean Set Operations 535
12.3 Primitive Instancing 539
12.4 Sweep Representations 540
12.5 Boundary Representations 542
12.6 Spatial-Partitioning Representations 548
12.7 Constructive Solid Geometry 557
12.8 Comparison of Representations 558
12.9 User Interfaces for Solid Modeling 561
12.10 Summary 561
Exercises 562

CHAPTER 13
ACHROMATIC AND COLORED LIGHT **563**

13.1 Achromatic Light 563
13.2 Chromatic Color 574
13.3 Color Models for Raster Graphics 584
13.4 Reproducing Color 599
13.5 Using Color in Computer Graphics 601
13.6 Summary 603
Exercises 603

CHAPTER 14
THE QUEST FOR VISUAL REALISM **605**

14.1 Why Realism? 606
14.2 Fundamental Difficulties 607
14.3 Rendering Techniques for Line Drawings 609

14.4 Rendering Tech
14.5 Improved Objec
14.6 Dynamics . .
14.7 Stereopsis . .
14.8 Improved Displ
14.9 Interacting with
14.10 Aliasing and An
14.11 Summary . . .
Exercises . . .

CHAPTER 15
VISIBLE-SURFACE

15.1 Functions of Tw
15.2 Techniques for E
15.3 Algorithms for V
15.4 The z-Buffer Alg
15.5 List-Priority Alg
15.6 Scan-Line Algori
15.7 Area-Subdivision
15.8 Algorithms for C
15.9 Algorithms for C
15.10 Visible-Surface R
15.11 Summary . . .
Exercises . . .

CHAPTER 16
ILLUMINATION AN

16.1 Illumination Mod
16.2 Shading Models f
16.3 Surface Detail
16.4 Shadows . . . .
16.5 Transparency . .
16.6 Interobject Reflec
16.7 Physically Based
16.8 Extended Light S
16.9 Spectral Sampling
16.10 Improving the Ca
16.11 Global Illuminatic
16.12 Recursive Ray Tra
16.13 Radiosity Method
16.14 The Rendering Pi
16.15 Summary . . . .
Exercises . . . .

occupancy enumeration is often used in biomedical applications to represent volumetric data obtained from sources such as computerized axial tomography (CAT) scans.

For all of its advantages, however, spatial-occupancy enumeration has a number of obvious failings that parallel those of representing a 2D shape by a 1-bit-deep bitmap. There is no concept of "partial" occupancy. Thus, many solids can be only approximated; the torus of Fig. 12.20 is an example. If the cells are cubes, then the only objects that can be represented exactly are those whose faces are parallel to the cube sides and whose vertices fall exactly on the grid. Like pixels in a bitmap, cells may in principle be made as small as desired to increase the accuracy of the representation. Space becomes an important issue, however, since up to n^3 occupied cells are needed to represent an object at a resolution of n voxels in each of three dimensions.

12.6.3 Octrees

Octrees are a hierarchical variant of spatial-occupancy enumeration, designed to address that approach's demanding storage requirements. Octrees are in turn derived from *quadtrees*, a 2D representation format used to encode images (see Section 17.7). As detailed in Samet's comprehensive survey [SAME84], both representations appear to have been discovered independently by a number of researchers, quadtrees in the late 1960s to early 1970s [e.g., WARN69; KLIN71] and octrees in the late 1970s to early 1980s [e.g., HUNT78; REDD78; JACK80; MEAG80; MEAG82a].

The fundamental idea behind both the quadtree and octree is the divide-and-conquer power of binary subdivision. A quadtree is derived by successively subdividing a 2D plane in both dimensions to form quadrants, as shown in Fig. 12.21. When a quadtree is used to represent an area in the plane, each quadrant may be full, partially full, or empty (also called black, gray, and white, respectively), depending on how much of the quadrant intersects the area. A partially full quadrant is recursively subdivided into subquadrants. Subdivision continues until all quadrants are homogeneous (either full or empty) or until a predetermined cutoff depth is reached. Whenever four sibling quadrants are uniformly full or empty, they are deleted and their partially full parent is replaced with a full or empty node. (A bottom-up approach can be used instead to avoid this deletion and merging process [SAME90b].) In Fig. 12.21, any partially full node at the cutoff depth is classified as full. The successive subdivisions can be represented as a tree with partially full quadrants at the internal nodes and full and empty quadrants at the leaves, as shown in Fig. 12.22.

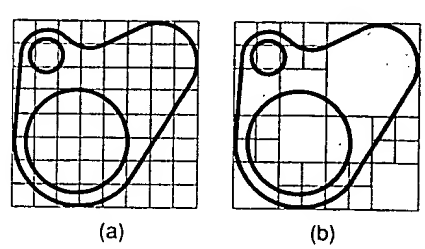

Fig. 12.21 An object represented using (a) spatial-occupancy enumeration (b) a quadtree.

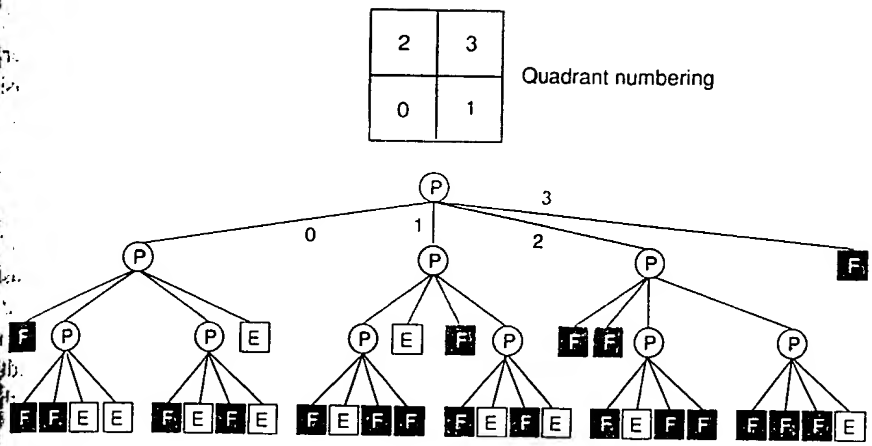

Fig. 12.22 Quadtree data structure for the object in Fig. 12.21. F = full, P = partially full, E = empty.

This idea can be compared to the Warnock area-subdivision algorithm discussed in Section 15.7.1. If the criteria for classifying a node as homogeneous are relaxed, allowing nodes that are above or below some threshold to be classified as full or empty, then the representation becomes more compact, but less accurate. The octree is similar to the quadtree, except that its three dimensions are recursively subdivided into octants, as shown in Fig. 12.23.

Quadrants are often referred to by the numbers 0 to 3, and octants by numbers from 0 to 7. Since no standard numbering scheme has been devised, mnemonic names are also used. Quadrants are named according to their compass direction relative to the center of their parent: NW, NE, SW, and SE. Octants are named similarly, distinguishing between left (L) and right (R), up (U) and down (D), and front (F) and back (B): LUF, LUB, LDF, LDB, RUF, RUB, RDF, and RDB.

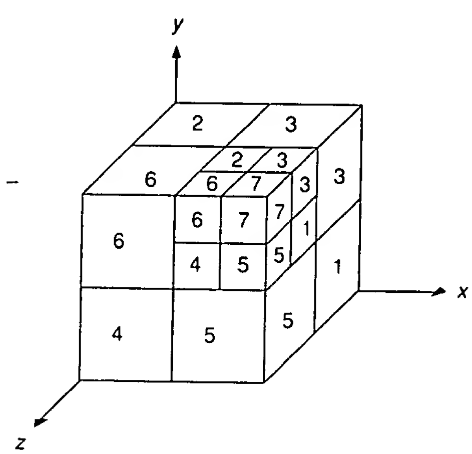

Fig. 12.23 Octree enumeration. Octant 0 is not visible.

With the exception of a few worst cases, it can be shown that the number of nodes in a quadtree or octree representation of an object is proportional to the object's perimeter or surface, respectively [HUNT78; MEAG80]. This relation holds because node subdivision arises only from the need to represent the boundary of the object being encoded. The only internal nodes that are split are those through which part of the boundary passes. Thus, any operation on one of these data structures that is linear in the number of nodes it contains also executes in time proportional to the size of its perimeter or area.

Although the divide-and-conquer approach of the quadtree and octree can be generalized to objects of arbitrary dimension, it is also possible to represent objects using only binary trees. Rather than dividing along all axes at each node of the tree, a *bintree* partitions space into equal halves about a single axis at each node, cycling through a new axis at each level [TAMM84]. A bintree often has more nodes than its equivalent quadtree or octree, but has at most the same number of leaves; as well, many processing algorithms can be formulated more simply for bintrees.

Boolean set operations and transformations. Much work has been done on developing efficient algorithms for storing and processing quadtrees and octrees [SAME84; SAME90a; SAME90b]. For example, Boolean set operations are straightforward for both quadtrees and octrees [HUNT79]. To compute the union or intersection U of two trees, S and T, we traverse both trees top-down in parallel. Figure 12.24 shows the operations for quadtrees; the generalization to octrees is straightforward. Each matching pair of nodes is examined. Consider the case of union. If either of the nodes in the pair is black, then a corresponding black node is added to U. If one of the pair's nodes is white, then the corresponding node is created in U with the value of the other node in the pair. If both nodes of the pair are gray, then a gray node is added to U, and the algorithm is applied recursively to the pair's children. In this last case, the children of the new node in U must be inspected after the algorithm has been applied to them. If they are all black, they are deleted and their parent in U is changed from gray to black. The algorithm for performing intersection is similar, except the roles of black and white are interchanged. If either of the nodes in a pair is white, then a corresponding white node is added to U. If one of the pair's nodes is black, then the corresponding node is created in U with the value of the other node in the pair. If both nodes of the pair are gray, then a gray node is added to U, and the algorithm is applied recursively to the pair's children. As in the union algorithm, if both nodes are gray, then after the algorithm has been applied to the children of the new node in U, the children must be inspected. In this case, if they are all white, they are deleted and their parent in U must be changed from gray to white.

It is easy to perform simple transformations on quadtrees and octrees. For example, rotation about an axis by multiples of 90° is accomplished by recursively rotating the children at each level. Scaling by powers of 2 and reflections are also straightforward. Translations are somewhat more complex, as are general transformations. In addition, as in spatial-occupancy enumeration in general, the problem of aliasing under general transformations is severe.

Neighbor finding. One important operation in quadtrees and octrees is finding a node's *neighbor*; that is, finding a node that is adjacent to the original node (sharing a face, edge, or vertex) and of equal or greater size. A quadtree node has neighbors in eight possible

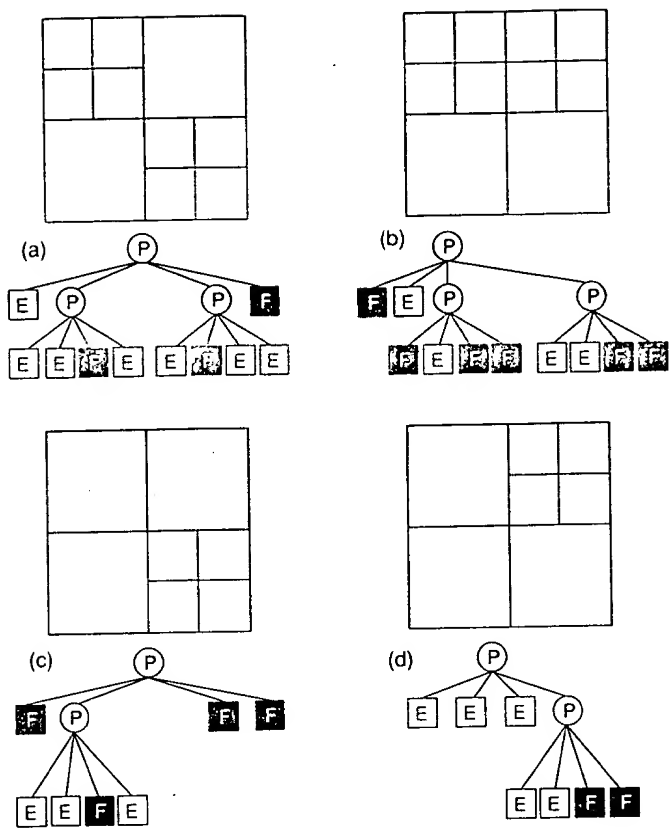

Fig. 12.24 Performing Boolean set operations on quadtrees. (a) Object S and its quadtree. (b) Object T and its quadtree. (c) $S \cup T$. (d) $S \cap T$.

directions. Its N, S, E, W neighbors are neighbors along a common edge, whereas its NW, NE, SW, and SE neighbors are neighbors along a common vertex. An octree node has neighbors in 26 possible directions: 6 neighbors along a face, 12 neighbors along an edge, and 8 neighbors along a vertex.

Samet [SAME89a] describes a way to find a node's neighbor in a specified direction. The method starts at the original node and ascends the quadtree or octree until the first common ancestor of the original node and neighbor is found. The tree is then traversed downward to find the desired neighbor. Two problems must be solved efficiently here: finding the common ancestor and determining which of its descendants is the neighbor. The simplest case is finding an octree node's neighbor in the direction d of one of its faces: L, R, U, D, F, or B. As we ascend the tree starting at the original node, the common ancestor will be the first node that is not reached from a child on the node's d side. For example, if the search is for an L neighbor, then the first common ancestor is the first node that is not reached from an LUF, LUB, LDF, or LDB child. This is true because a node that has been reached from one of these children cannot have any child that is left of (is an L neighbor of)

the original node. When the common ancestor is found, its subtree is descended in a mirror-image of the path from the original node to the ancestor, reflected about the common border. Only part of the reflected path is followed if the neighbor is larger than the original node.

A similar method can be used to find a quadtree node's neighbor in the direction of one of its edges. For example, to find the N neighbor of node *A* of Fig. 12.25, we begin at *A*, which is a NW child, and follow the path depicted by the thick line in the figure. We ascend from the NW to its parent, from the NW again to its grandparent, and finally from the SW to its great grandparent, the root, stopping because we have approached it from an S node, rather than from an N node. We then follow the mirror-image path downward (reflected about the N–S border), to the root's NW child, and finally to this node's SW child, which is a leaf. Samet [SAME89a] describes the more elaborate algorithms for finding edge and vertex neighbors in octrees, and provides an elegant recursive implementation that uses table lookup to perform such operations as computing the reflected path.

Linear notations. Although a tree data structure with pointers might at first seem necessary to represent a quadtree or octree, pointerless notations are possible. In the *linear quadtree* or *linear octree* notation [GARG82], each full node is represented as a sequence of digits that represents its fully qualified address. There are as many digits as there are levels. Only black leaf nodes need to be stored to represent the object. Nodes that are not at the lowest level include an additional padding character (e.g., "X") in each of their trailing

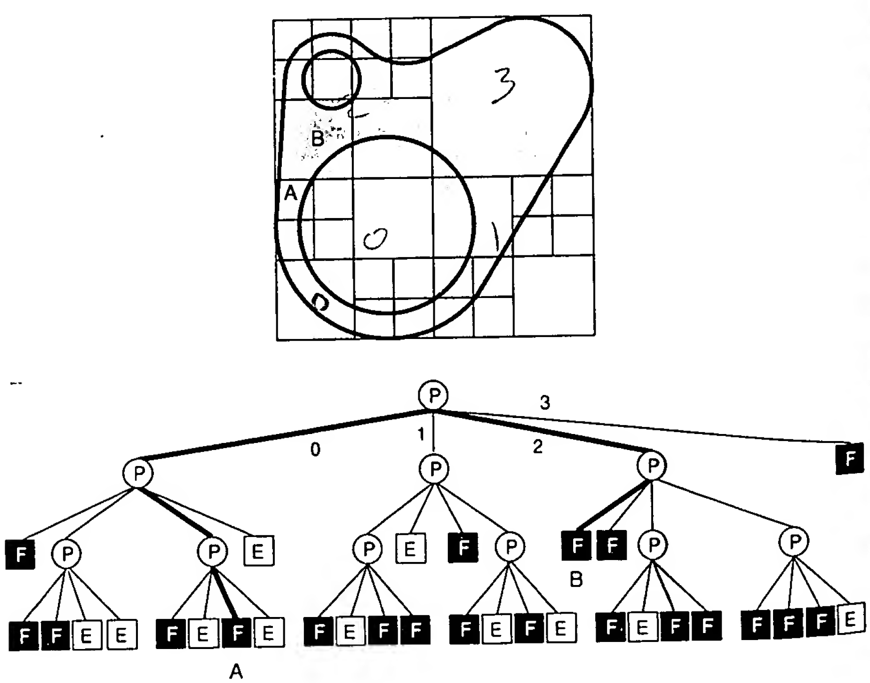

Fig. 12.25 Finding the neighbor of a quadtree node.

digits. For example, a linear octree can be encoded compactly using base-9 numbers (conveniently represented with 4 bits per digit), with 0 through 7 specifying octants and 8 indicating padding. The nodes in the linear octree are stored in sorted order, which represents a postorder traversal of the octree. For example, the linear quadtree representation of the object in Fig. 12.21 is 00X, 010, 011, 020, 022, 100, 102, 103, 12X, 130, 132, 20X, 21X, 220, 222, 223, 230, 231, 232, 3XX.

A number of operations can be performed efficiently with the linear-quadtree or linear-octree representation. For example, Atkinson, Gargantini, and Ramanath [ATKI84] present an algorithm for determining the voxels that form an octree's border by making successive passes over a list of the octree's nodes. Full nodes of the largest size are considered first. Each such node that abuts full nodes of the same size on all six sides is internal to the object and is therefore not part of the border; it is eliminated from the list. (Each neighbor's code may be derived by simple arithmetic manipulation of the node's code.) Any other node of this size may contain voxels that are part of the border; each of these nodes is broken into its eight constituent nodes, which replace it in the list. The algorithm is repeated for successively smaller node sizes, stopping after voxel-sized nodes are considered. Those nodes remaining are all the voxels on the object's border.

PM octrees. A number of researchers have developed hybrid representations that combine octrees and b-reps to maintain the precise geometry of the original b-rep from which the object is derived [HUNT81; QUIN82; AYAL85; CARL85; FUJI85]. These *PM octrees* (*PM* stands for Polygonal Map) expand on a similar quadtree variant [SAME90a]. The octree is recursively divided into nodes until the node is one of five different leaf types. In addition to full and empty, three new leaf nodes are introduced that are actually special kinds of partially full nodes: vertex nodes, which contain a single vertex and its connected faces and edges; edge nodes, which contain part of a single edge and its faces; and surface nodes, which are cut by a piece of a single face. Restricting the new leaf types to a set of simple geometries, each of which divides the node into exactly two parts, simplifies the algorithms that manipulate the representation, such as Boolean set operations [CARL87; NAVA89].

Section 18.11.4 discusses a number of architectures based on voxel and octree models. Section 15.8 discusses visible-surface algorithms for octrees.

12.6.4 Binary Space-Partitioning Trees

Octrees recursively divide space by planes that are always mutually perpendicular and that bisect all three dimensions at each level of the tree. In contrast, *binary space-partitioning* (BSP) *trees* recursively divide space into pairs of subspaces, each separated by a plane of arbitrary orientation and position. The binary-tree data structure created was originally used in determining visible surfaces in graphics, as described in Section 15.5.2. Thibault and Naylor [THIB87] later introduced the use of BSP trees to represent arbitrary polyhedra. Each internal node of the BSP tree is associated with a plane and has two child pointers, one for each side of the plane. Assuming that normals point out of an object, the left child is behind or inside the plane, whereas the right child is in front of or outside the plane. If the half-space on a side of the plane is subdivided further, then its child is the root of a subtree; if the half-space is homogeneous, then its child is a leaf, representing a region either

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File Format: Rich Text Format - View as HTML
... ufi 6, 6,i - **unique** feature **identifier**. ... units are coded by the unit item in the **polygon** attribute. ... with the codes used matching the nomenclature on the map **face**: ...
www.georeality.com.au:81/biab/Metadata/ geology/mur_250/Geology_amd.rtf - Similar pages

TXT2PCX.COM Is a **unique**, memory resident, file utility which will ...
Oktalyzer Formats
myfileformats.com/index.php/c-functions/ packet/.reg/bank.html - 7k - Cached - Similar pages

> The PLY **Polygon** File Format
> AVI File format
> myfileformats.com/index.php/tif/ general/cookie/isff.html - 7k - Cached - Similar pages
> [More results from myfileformats.com]

[PPT]RASTER VECTOR
File Format: Microsoft Powerpoint 97 - View as HTML
... used for mapping and analyzing things that exist and events that happen on the **face** of the ... 1. Digitize a **unique** text entity within each **polygon** area. ...
www.geology.fau.edu/course_info/spring02/ geo4151/gistopic7students.ppt - Similar pages

[PDF]OpenMesh – a generic and efficient **polygon** mesh data structure
File Format: PDF/Adobe Acrobat - View as HTML

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polygon face path | Google Search

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Searched the web for polygon face path. Results **1** - **10** of about **16,000**. Search took **0.16** seconds.

[vtkusers] Contouring **polygon** & outline **path**
... FONT **face**=3DArial size=3D2>For modeling operation, I have to take = an outline=20
and expand it while moving it along a **path** (concave and convexe = **polygon**). ...
public.kitware.com/pipermail/vtkusers/ 2002-October/014017.html - 6k - Cached - Similar pages

www-svg@w3.org from March 2003: Re: Updated test suite?
... animateTransform | g | defs | use | switch | image | **path** | rect | circle |line
| ellipse | polyline | **polygon** | text | a | font | font-**face**)*, got (style ...
lists.w3.org/Archives/Public/www-svg/2003Mar/0046.html - 9k - Cached - Similar pages

An Optimal Data Structure for Shortest Rectilinear **Path** Queries ...
... the Largest Axis-Aligned Rectangle in a **Polygon** in - Ralph Boland Jorge (Correct)
On Geometric **Path** Query Problems ... Segmentation of a Head into **Face**, Ears, Neck ...
citeseer.nj.nec.com/400327.html - 25k - Cached - Similar pages

Attribute Index - SVG 1.1 - 20020215
... altGlyphItem, font-**face**-src, metadata, svg, g, defs, desc, title, symbol, use, image,
switch, style, **path**, rect, circle, ellipse, line, polyline, **polygon**, text ...
www.w3.org/TR/2002/WD-SVG11-20020215/attindex.html - 101k - Cached - Similar pages

WebWorlds: Polygons, Sweeping, Tipping and Lathing
... Tip - This tool sweeps a selected **polygon**, **face**, or group of faces to a point ... Lathe
- This tool sweeps a shape along a modifiable circular or spiral **path**. ...
www.msu.edu/user/ionescua/pioneer/cpwk2_4.htm - 6k - Cached - Similar pages

A **face** for a robot: The **path** to creating a **face** to socially ...
A **face** for a robot: The **path** to creating a ... a flip-pack animation of the **face** opening
and ... by 1974, Parke used Henri Gouraud's smooth **polygon** shading algorithm ...
www.its.caltech.edu/~vikram/cs286/report/ - 101k - Cached - Similar pages

MEL How-To
... How do I determine the **path** for a script while it is executing; for example, to
load another file in the ... How do I get the normal vector for a **polygon face**? ...
www.ewertb.com/maya/mel/ - 16k - Cached - Similar pages

Conformance
... Verbose level = 2. Random number seed = 1. **Path** inactive. Visual Report. Display
ID = 35. ... Quad Rasterization test passed. **Polygon Face** test passed. ...
www.mesa3d.org/conform.html - 19k - Cached - Similar pages

Maya Mel Scripts, MAYA Mel Scripts, MEL, Scripts for Maya
... This script simulates subdivision modeling with existing Maya Complete **polygon** tools. ... **Face**
Path Selection Tool v1.0:: [By Andras POLONYI] - [Works on: 3.x ...
www.highend3d.com/maya/mel/ ?group=melscripts&section=polygon - 101k - Cached - Similar pages

[DOC]PolarEyez is a new focus+context visualization for ...
File Format: Microsoft Word 2000 - View as HTML
... Figure 3.5: Rays are (a) grouped by **face**, and (b) ordered within a **face** by a scan-line

path. ... Hyper-cube maps to a **polygon** with equal sides and angles (black ...
infovis.cs.vt.edu/multid/thesis%20writeup/CHAP3.doc - Similar pages

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polygon face path | Google Search | Search within results

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Searched the web for **catmul clark**. Results **1** - **10** of about **49**. Search took **0.17** seconds.

Did you mean: ***catmull*** clark

Multiresolution Wavelet Representations for Arbitrary Meshes (...
... Singularity detection and processing with wavelets - Mallat, Hwang - 1992 160 spline surfaces on arbitrary topological meshes (context) - **Catmul**, **Clark** et al. ...
citeseer.nj.nec.com/natsev97multiresolution.html - 25k - Cached - Similar pages

[PPT]Title
File Format: Microsoft Powerpoint 97 - View as HTML
... topologically restricted. **Catmul/Clark** Subdivision. Why? ... Generalization of **Catmul/Clark**: semi-sharp features controlled by edge sharpness s. Hybrid Subdivision: ...
www.cs.berkeley.edu/~j-yen/cs285/derose.ppt - Similar pages

Untitled
... The scheme to implement may be Loop subdivision surfaces or **Catmul-Clark** subdivision surfaces with a meaningfull user interface. ...
www.cs.bilkent.edu.tr/~gudukbay/cs466/ project_list/project_list.html - 6k - Cached - Similar pages

[PPT]kopernik.cc.fmph.uniba.sk/~leskovsky/SubdivSurf.ppt
File Format: Microsoft Powerpoint 97 - View as HTML
... . *. *. Midedge. C1. *. *. *. Doo-Sabin. C1. *. *. *. Kobbelt. C2/C1. *. *. *. **Catmul-Clark**. C1. *. *. *. Butterfly. C2/C1. *. *. *. Loop. Smoothness. Vertex split. Face split. Triangle. Quad. ...
Similar pages

Who needs Bryce, Use Blender... - Open 3D Forum
... the name says it all, note I heard ball-joint IKA is being released on the next update, it already supports **catmul-clark** patches (aka MetaNURBS) a decimator ...
www.designcommunity.com/messages/9359.html - 7k - Cached - Similar pages

Caltech Computer Science Technical Reports - Is this a ...
... Extensions to other popular uniform primal subdivision schemes such as **Catmul-Clark**, and dual schemes such as Doo-Sabin, are relatively strightforward but will ...
caltechcstr.library.caltech.edu/archive/00000171/ - 7k - Cached - Similar pages

Character Modeling: Chapter 1
... I used a subdivision mesh (old s-mesh) to smooth out the model, but you could also use a plain mesh with(out) smooth rendering, **catmul-clark** (now in Blender ...
neenjatech.org/projects/character/body/page1.html - 4k - Cached - Similar pages

:: El Portal del 3D y la Animación :: 3DyAnimacion.com
... best ones. To be more specific, polygons used with Subdivision Surfaces technique (like **Catmul-Clark** in RenderMan). The NURBS are ...
www.3dyanimacion.com/entrevistas/ entrevistas.cfm?link=fcortinaeng - 44k - Cached - Similar pages
[More results from www.3dyanimacion.com]

Subdivision Surfaces
... I hope to add a **Catmul/Clark** filter by the end of the year. There are

several examples in graphics/examplesTcl to illustrate the filters. ...
public.kitware.com/pipermail/vtkusers/ 1999-October/002473.html - 4k - Cached - Similar pages

forcefield gallery
... I have some normals issues with the s-meshes (I might just subdivide and smooth them myself, or try that **catmul-clark** plugin...) posted by chris hillman at 12.2 ...
forcefield.tripod.com/gallery.html - 7k - Cached - Similar pages

Did you mean to search for: ***catmull*** clark

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catmul clark | Google Search | Search within results

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Did you mean: ***catmull*** clark data structure

[PPT]kopernik.cc.fmph.uniba.sk/~leskovsky/SubdivSurfEn.ppt
File Format: Microsoft Powerpoint 97 - View as HTML
... . *. *. **Catmul-Clark**. C1. *. *. *. ... Used technology. **Data** structures. The implementation of the subdivision schemes. ... The use in commercial software. The **Structure**. Input: ...
Similar pages

[PDF]IBM Research Report
File Format: PDF/Adobe Acrobat - View as HTML
... to other popular uni- form primal subdivision schemes such as **Catmul-Clark**, and dual ... An algorithm based on Tarjan's fast union-find **data structure** [9] can be ...
researchweb.watson.ibm.com/people/ t/taubin/pdfs/Taubin-ibm21880.pdf - Similar pages

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... Clustering / **data** mining; **Data structure**. Examination. Written exam. ... B-rep **data** structures. ... Subdivision surfaces: **Catmul-Clark**, Butterfly and Loop's scheme. ...
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> ... Clustering / **data** mining; **Data structure**. ... diagram, meshes, mesh implication, B-rep **data** structures ... Subdivision surfaces: **Catmul-Clark**, Butterfly and Loop's scheme ...
> www-ensimag.imag.fr/formations/enseignements/ 3e-annee/2001-2002/im-rv.html - 41k - Cached - Similar pages

[PS]caltechcstr.library.caltech.edu/archive/00000171/00/postscript.ps
File Format: Adobe PostScript - View as Text
... to other popular uniform primal subdivision schemes such as **Catmul-Clark**, and dualschemes ... An algorithm based on Tarjan's fast union-find **data structure** [9] can ...
Similar pages

> [PDF]Is This A Quadrisected Mesh ?
> File Format: PDF/Adobe Acrobat - View as HTML
> ... to other popular uni- form primal subdivision schemes such as **Catmul-Clark**, and dual ... An Å algorithm based on Tarjan's fast union-find **data structure** [9] can ...
> caltechcstr.library.caltech.edu/archive/ 00000171/01/postscript.pdf - Similar pages

BIBLIOGRAPHY
... Background on Smooth Surfaces. E. **Catmul** and J. **Clark**: "Recursively generated B-spline surfaces ... - Effective display of complex **data** using just two dimensions. ...
www.cs.berkeley.edu/~sequin/CS285/bibl.html - 11k - Cached - Similar pages

Programming question for Bjorn - www.ezboard.com
... Where did you go to learn about the wing-edge **data structure** and all the ... d part I can answer that one he didnt wings uses **catmul-clark** subdivision algorythms ...
pub33.ezboard.com/ fnendowingsmiraifrm8.showMessage?topicID=168.topic - 22k - Cached - Similar pages

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-	25	lounsbery	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:50
-	1	(polygon$3 or mesh) with level with path with vertex	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:53
-	156	(polygon$3 or mesh) near2 data near structure	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:53
-	0	((polygon$3 or mesh) near2 data near structure) same (face or patch) near identif$6	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:54
-	0	((polygon$3 or mesh) near2 data near structure) same (face or patch) same path same level same vertex	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:55
-	27	((polygon$3 or mesh) near2 data near structure) same (face or patch)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:54
-	21	((polygon$3 or mesh) near2 data near structure) and base near (polygon or mesh or patch)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:58
-	1	base near (polygon or mesh or patch) same path near (mesh or patch)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:59
-	0	catmul near clark	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 12:59
-	20	catmul$clark	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:05
-	828	(polygon or mesh) and (face or patch) and level and path and vertex	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:05
-	13	(polygon or mesh) and (face or patch) and (level same path same vertex)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:12
-	8	(polygon or mesh) and base near (face or patch) and (face or patch) near path	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:13
-	0	base near (face or patch) near identifier	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:14

-	21626	base near (face or patch)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:14
-	60	base near (face or patch) with identif$6	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:14
-	12	(base near (face or patch) with identif$6) and polygon	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:17
-	15	("4618924" | "4752352" | "4789931" | "4837703" | "4863538" | "4866631" | "4907164" | "4938816" | "4944817" | "4949270" | "4961041" | "4996010" | "5017753" | "5053090" | "5432704").PN.	USPAT	2003/08/12 13:16
-	134	(quadtree or octree) with data near structure	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:19
-	28	((quadtree or octree) with data near structure) same tree	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:18
-	1	(((quadtree or octree) with data near structure) same tree) same vertex	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:18
-	92	(quadtree or octree) near2 data near structure	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:31
-	58	(polygon or mesh) same (patch or face) same path same level	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:32
-	3	((polygon or mesh) same (patch or face) same path same level) and unique	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:33
-	6	unique near (face or patch) near identif$6	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:34
-	1085	(face or patch) near identif$6	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:34
-	411263	((face or patch) near identif$6) smae (polygon or mesh)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:35
-	34	((face or patch) near identif$6) same (polygon or mesh)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:42

-	623	(polygon or mesh) same (file or data) near structure	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:43
-	0	((polygon or mesh) same (file or data) near structure) and (patch or face) near name	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:43
-	292	(patch or face) near name	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:43
-	0	((patch or face) near name) same (polygon or mesh)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:43
-	52	(polygon or mesh) same (face or patch) with (file or data) near structure	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:55
-	0	((polygon or mesh) same (face or patch) with (file or data) near structure) and base near face	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:45
-	0	((polygon or mesh) same (face or patch) with (file or data) near structure) and base near patch	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:45
-	0	((polygon or mesh) same (face or patch) with (file or data) near structure) and base near polygon	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:45
-	469	(382/154).CCLS.	USPAT	2003/08/12 13:45
-	91	((382/154).CCLS.) and (polygon or mesh)	USPAT	2003/08/12 13:45
-	56	(((382/154).CCLS.) and (polygon or mesh)) and level	USPAT	2003/08/12 13:46
-	63	(((382/154).CCLS.) and (polygon or mesh)) and base	USPAT	2003/08/12 13:46
-	3	(((382/154).CCLS.) and (polygon or mesh)) and base near (patch or mesh)	USPAT	2003/08/12 13:47
-	0	(polygon or mesh) and subdiv$6 and base near (mesh or polygon or face or patch or facet)	USPAT	2003/08/12 13:48
-	2369	(polygon or mesh) and subdiv$6 and (face or patch or facet)	USPAT	2003/08/12 13:48
-	96	(polygon or mesh) near2 subdiv$6 and (face or patch or facet)	USPAT	2003/08/12 13:48
-	42	(polygon or mesh) near2 subdiv$6 same (face or patch or facet)	USPAT	2003/08/12 13:52
-	424	(polygon or mesh) and path near2 (face or facet or patch)	USPAT	2003/08/12 13:53
-	244	((polygon or mesh) and path near2 (face or facet or patch)) and base	USPAT	2003/08/12 13:53
-	22	(polygon or mesh) and path near2 (face or facet or patch) same base	USPAT	2003/08/12 13:53
-	53	(polygon or mesh) same path near2 (face or facet or patch)	USPAT	2003/08/12 13:54
-	1476	"59" and vertex and level and base	USPAT	2003/08/12 13:54
-	0	((polygon or mesh) same path near2 (face or facet or patch)) and vertex and level and base	USPAT	2003/08/12 13:54
-	0	((polygon or mesh) same path near2 (face or facet or patch)) and vertex and level	USPAT	2003/08/12 13:54
-	22	(polygon or mesh) with path near2 (face or facet or patch)	USPAT	2003/08/12 13:55

-	0	((382/154).CCLS.) and path near (face or facet or patch)	USPAT	2003/08/12 13:55
-	23	((382/154).CCLS.) and path	USPAT	2003/08/12 13:55
-	0	path with (polygon or mesh) with (face or patch) same (file or data) near structure	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 13:56
-	18	((polygon or mesh) same (file or data) near structure) same path	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/08/12 14:02
-	2959	(345/419-428).CCLS.	USPAT	2003/08/12 14:02
-	471	((345/419-428).CCLS.) and (mesh or polygon$4).ab.	USPAT	2003/08/12 14:02
-	73	(((345/419-428).CCLS.) and (mesh or polygon$4).ab.) and level and path and vertex	USPAT	2003/08/12 14:09
-	0	(((345/419-428).CCLS.) and (mesh or polygon$4).ab.) and path near (face or facet or patch)	USPAT	2003/08/12 14:09
-	10	(((345/419-428).CCLS.) and (mesh or polygon$4).ab.) and base near face	USPAT	2003/08/12 14:10
-	42	base with subdivid$5 with level	USPAT	2003/08/12 14:11
-	0	base with subdivid$5 with level with (polygon or mesh) with face	USPAT	2003/08/12 14:11
-	5	base with subdivid$5 with level and polygon	USPAT	2003/08/12 14:12
-	4	unique near (face or patch) near identif$6	USPAT	2003/08/12 14:12
-	5	unique near (face or patch) near (name or identif$6)	USPAT	2003/08/12 14:12